



## Photoluminescence Study of Europium Doped $Gd_3Al_5O_{12}$ Phosphor

**B. Vinod Kumar<sup>1</sup>, B. Walter Ratna Kumar<sup>2</sup>, P. Kamala<sup>3</sup>,  
T. Malathi Rekha<sup>4</sup> and K.V.R. Murthy<sup>5</sup>**

<sup>1</sup>*Department of Chemistry, Krishna University, Machilipatnam,*

<sup>2</sup>*Department of Physics, PBN College, Nidubrolu, A.P.,*

<sup>3</sup>*The Hindu College, Machilipatnam, A.P., India,*

<sup>4</sup>*SPMH Kalasala Machilipatnam,*

<sup>5</sup>*Display Materials Laboratory, Applied Physics Dept., Faculty of Technology and Engineering,*

*M. S. University of Baroda, Vadodara, Gujarat, India*

*Email: walter\_rkb@yahoo.com*

The present paper reports the synthesis and photoluminescence studies of  $Gd_3Al_5O_{12}$  Phosphor doped with 1% of Europium, via Solid State Reaction (SSR) method. The Phosphor was prepared at a calcinating temperature of 900 °C and 1200°C in a muffle furnace in open air. The Phosphor appears white in Colour. The excitation spectrum was taken at 613nm. The photoluminescence emission was studied at 254 and 276nm excitations. Emission spectrum at 613nm excitation spreads from 220 to 320nm with prominent peaks at 256 and 276nm. So that the emission spectra was studied for 254 and 276nm. The main emissions were observed around blue and orange-red regions.

### INTRODUCTION

Lanthanide ions show excellent spectroscopic properties in 3+ state. They have narrow emission bands, and large Stokes shift (difference between the excitation and emission energies) and with the lifetime in the order of  $10^{-3}$ seconds. that Therefore, they play prominent role as dopants in host matrix. It was reported Lanthanide oxide nano particles used as luminescent probes in bioanalysis because of their unique spectral properties, photostability and low cost synthesis. For all the matrixes, the excitation spectra of  $Eu^{3+}$  displayed a broad band at shorter wavelength, assigned to the charge transfer between the ligand and the metal ( $O^{2-} \rightarrow Eu^{3+}$  or  $S^{2-} \rightarrow Eu^{3+}$ ) and to the  $f-f$  transitions of the  $Eu^{3+}$  excited state. Some spectra presented a band relative to the excited state of the  $Gd^{3+}$  ion, indicating  $Gd^{3+} \rightarrow Eu^{3+}$  energy transfer. The emission spectra of  $Eu^{3+}$ , excited at different wavelengths, exhibited narrow lines between 500 and 750 nm, relative to the typical transition from the excited level to manifold level ( $^5D_0 \rightarrow ^7F_2$ , with  $J = 0, 1, 2, 3,$  and  $4$ ). The more intense band of the matrixes corresponded to the hypersensitive transition  $^5D_0 \rightarrow ^7F_2$ , with dipole-electric character, detected with maximum at approximately 615 nm. Yttrium aluminum garnet ( $Y_3Al_5O_{12}$ , YAG) is an advanced ceramic material with interesting optical and mechanical properties. A host crystal with an yttrium aluminum garnet structure has the advantage of a relatively stable lattice & large thermal conductivity. Thus, YAG can be used as the host lattice for a number of rugged phosphor systems. It is an important crystal for fluorescence and solid state lasers. Eu, Tb-activated YAG phosphor has luminescence characteristic narrow band phosphor suitable for contrast-enhanced display applications in high ambient illumination conditions. The investigators out of their enthusiasm want to investigate the effect of Europium ion in the  $Gd_3Al_5O_{12}$  phosphor.

## EXPERIMENTAL

The present paper reports the Synthesis and Photoluminescence study of  $Gd_3Al_5O_{12}$  phosphor doped with Eu(1%). Gadolinium Oxide ( $Gd_2O_3$ ) and Aluminium Oxide ( $Al_2O_3$ ) were taken in a stoichiometry of 3:5 ratio to prepare  $Gd_3Al_5O_{12}$ . The starting compounds along with 1% Europium Oxide were taken and they were mixed and grounded thoroughly in an agate mortar with pestle for 45 minutes. Acetone medium was used intermediately in the grinding procedure to get fine grain and uniform size. The obtained powder mixture was annealed in a muffle furnace at a heating rate of 6° C per minute, up to the temperatures of 900°C and 1200°C separately and soaked for 3 hours and allowed to cool naturally to room temperature. They were synthesized using Solid State Reaction (SSR) method in open air atmosphere. The obtained powders seem to be white in colour. They were taken in to agate mortar and ground with pestle to obtain fine grained powder. Photoluminescence spectra were recorded at room temperature using Spectrofluorophotometer having Xenon lamp as excitation source.

## CHARACTERIZATION

### Photoluminescence Study

#### *Excitation Spectrm*

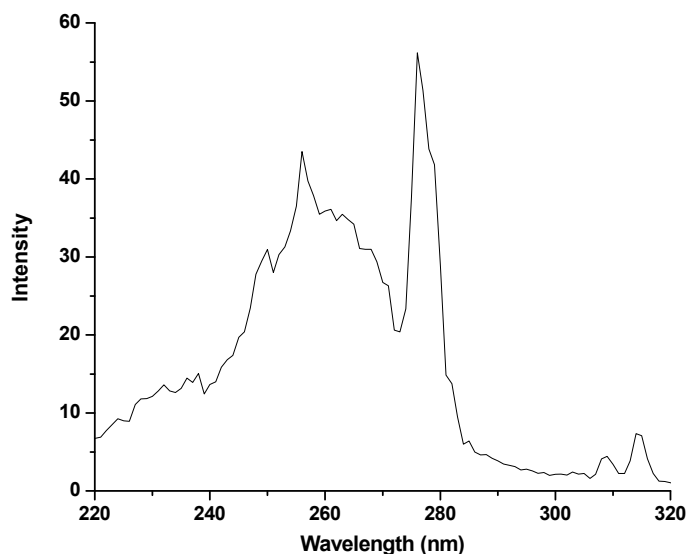


Fig.1: Excitation spectrum of 900°C heated  $Gd_3Al_5O_{12}:Eu$  1% monitored at 613 nm

Photoluminescence spectra were recorded at room temperature using Spectrofluoro-photometer having Xenon lamp as excitation source. Fig.1 shows the excitation spectrum monitored at 613nm for 900°C heated sample. It spreads from 220 to 320nm with the prominent peaks at 256nm and 276nm with good intensity. The excitation spectrum of 1200°C heated sample doesn't show much difference and the prominent peaks are at the same wavelengths.

**Emission Spectra**

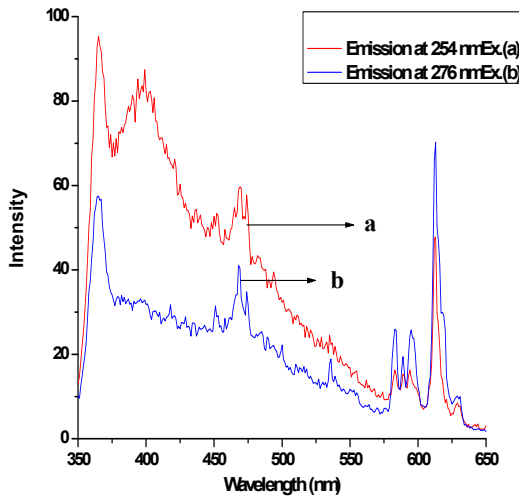


Fig.2: Emission Spectra of  $Gd_3Al_5O_{12}:Eu1\%$  at  $900^\circ C$  with different Excitations

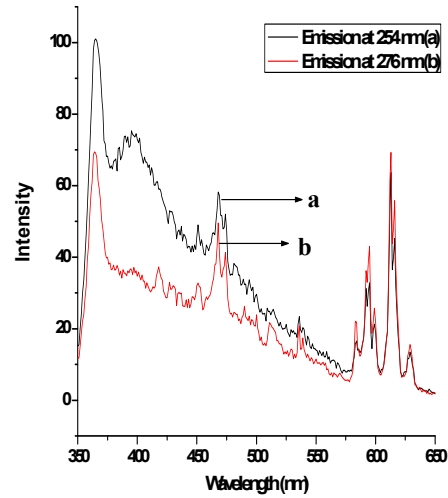


Fig.3: Emission Spectra of  $Gd_3Al_5O_{12}:Eu1\%$  at  $1200^\circ C$  with different Excitations

The excitation spectrum shows prominent peaks at 256 and 276 nm. But the emission spectra were taken at the excitations of 254 and 267nm. The 254 nm excitation was selected to record emission spectra, since it was the available excitation for the fabrication of the lamps and has been the mercury resonance wavelength. Fig.2 shows the emission spectra of  $Gd_3Al_5O_{12}$  phosphor heated at  $900^\circ C$  with 254 and 276 nm excitations. The emission spectrum spreads from 350 to 650nm with many spiky peaks. The sharp prominent emissions were observed at 595 and 613 nm with some minute peaks around them. From the figure, it should be known that the prominent bulge around 450nm may be due to Aluminium ion in the base compound. The peak at 536nm may be due to the presence of Gadolonium ion in the matrix of base compound. The peak at 365nm may be due to the presence of crystal field. Fig.3 shows the emission spectra of  $Gd_3Al_5O_{12}$  phosphor heated at  $1200^\circ C$  with 254 and 276 nm excitations. From the figures 2 and 3, it was observed that the prominent sharp peaks were evolved at 595 and 613nm along with some minor peaks around them. All of them were allowed transitions of Europium in  $3+$  state. A bulge around blue region with a minute peak at 468nm was observed. It may be due to the Aluminium ion in the base compound. The other minute peaks are evolved at 474, 536, 583, 599, 616 and 629 nm. All the emissions show highest intensity for 276nm excitation in comparison with 254nm excitation. The intensities around red region may be enhanced by increasing the concentration of Europium as dopant in the phosphor. The respective emission intensities for various excitation wavelengths for different temperatures were indicated in the tabularform.

**Table 1: The emissions and their respective intensities for different excitation wavelengths**

$\lambda_{ex}$ (nm)	Temperature °C	Emission wavelengths (nm)	Respective Emission Intensities
254	900	365,470,474,535,583,594,613	95,59,58,25,16,16,48
	1200	365,470,474,535,583,594,613	101,58,52,21,16,31,64
276	900	365,470,474,535,583,594,613	57,41,35,18,26,26,70
	1200	365,470,474,535,583,594,613	69,50,41,21,22,43,69

### TRANSITION MECHANISM

The peak at 470 nm is due to  $^5D_2 \rightarrow ^7F_0$  transition of aluminium ion and is due to magnetic dipole with energy 2.6398 eV. The peak at 474 nm is due to  $^5D_2 \rightarrow ^7F_1$  transition of Gadalonium and is due to magnetic dipole with energy 2.618 eV. The peak at 535 nm is due to  $^5D_1 \rightarrow ^7F_1$  transition of Gadalonium and is due to magnetic dipole with energy 2.319 eV. The peak at 583 nm is due to  $^5D_1 \rightarrow ^7F_1$  transition of Gadalonium and is due to magnetic dipole with energy 2.128 eV. The peak at 594 nm is due to  $^5D_0 \rightarrow ^7F_1$  transition of Europium and is due to magnetic dipole with energy 2.089 eV. The peak at 613 nm is due to  $^5D_0 \rightarrow ^7F_2$  transition of Europium and is due to electric dipole with energy 2.024 eV. The peak at 628 nm is due to  $^5D_0 \rightarrow ^7F_3$  transition of Europium and is due to electric dipole with energy 1.976 eV. All the emissions are allowed and are due to transitions of Europium ions in the host crystal.

### CONCLUSIONS

1. Gd<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> was successfully synthesized via Solid State Reaction method.
2. Europium were succeeded as dopants in Gd<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> system and has its own and allowed transitions.
3. The prominant peaks in the blue region at 468nm may be due to Aluminium ion transitions.
4. The effect of Europium in the matrix is to emit 613 and 628nm wavelengths. Increment in the concentration of Europium may enhance the intensities of the above emission wavelengths.
5. It seems to be the promising phosphor candidate that may be used in scintillation, electroluminescence and as a luminescent probe in bioanalysis applications.

### REFERENCES

- [1] E. Bulur, H.Y. Goksu, A. Wieser, M. Figel, A.M. Ozer, Radiat. Prot. Dosim. 65 (1996) 373.
- [2] Marcela Guedes Matos<sup>1</sup>, Gabriela Simões Freiria<sup>1</sup>, Lídia Resende Oliveira<sup>1</sup>, Emerson Henrique de Faria<sup>1</sup>, Paulo Sérgio Calefi<sup>1</sup>, Katia Jorge Ciuffi<sup>1</sup>, Lucas Alonso Rocha<sup>1</sup>, Eduardo José Nassar<sup>1</sup>, Marc Verelst<sup>2</sup>, Sémiyou A. Osseni<sup>2</sup>, and Séverine Lechevallier<sup>2</sup>
- [3] S.-M. Yeh, C.S. Su, Radiat. Prot. Dosim. 65 (1996) 359.
- [4] R.A. Rodriguez, E. De la Rosa, R. Melendrez, P. Salas, J. Castaneda, M.V. Felix, M. Barboza-Flores, Opt. Mater. 27 (2005) 1240.

- [5] R.A. Rodriguez, E. De la Rosa, L.A. Diaz-Torres, P. Salas, R. Melendrez, M. Barboza-Flores, *Opt. Mater.* 27 (2004) 293.
- [6] L. Liu, Y. Zhang, J. Hao, C. Li, Q. Tang, C. Zhang, Q. Su, *Physica status solidi (a)* 202 (2005) 2800.
- [7] D.L. Dexter, *J. Chem. Phys.* 21 (1953) 836.
- [8] G. Blasse. *Luminescent Materials*, Springer, Berlin (1994) 93.
- [9] Kee-Sun Sohn, Fung suk Park, Chang Hae Kim and Hee Dong Park, *J. Electrochem. Soc.*, 147 (11) (2000) 4368.
- [10] S. Shionoya, W. Yen, *Phosphor Handbook*, CRC Press, Boca Raton, (1999).